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RACLITE-IN-0157

Contract No. EP-S4-08-03

November 23, 2011

Terry Stilman
SNAFC - ERRB
61 Forsyth Street, SW
Atlanta, GA 30303

Subject: Transmittal of Final Human Health Risk Assessments for the Libby Sister Sites – GAO 148 – Task Order 011.

Dear Mr. Stilman:

Enclosed are two copies of the Final Human Health Risk Assessment for Libby Sister Site GAO 148. An electronic file of the same document has been sent to you, Greg Harper, and Tim Frederick through e-mail.

If you have any questions or comments on this matter please contact me.

Very truly yours,

James F. Walsh
Project Manager
Avatar Environmental

Enclosures

C: A. Ostrofsky (JMWA)
T. Woods (Avatar Environmental)

10863007

REMEDIAL ACTION CONTRACT (RAC) II LITE
IN EPA REGION 4

FINAL
HUMAN HEALTH RISK ASSESSMENT
FOR
VERMICULITE EXFOLIATION PLANT GAO 148
WOODRUFF, SOUTH CAROLINA

Prepared by:
J.M. Waller Associates, Inc.
100 Hartsfield Centre Parkway, Suite 610
Atlanta, Georgia 30354

Prepared for:
U.S. Environmental Protection Agency
61 Forsyth Street, 11th Floor
Atlanta, Georgia 30303

Contract No. EP-S4-08-03

Task Order 011

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Acronyms and Abbreviations

ABS	activity-base sampling
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CTE	central tendency exposure
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
f/cc	fibers per cubic centimeter
HHRA	Human Health Risk Assessment
IRIS	Integrated Risk Information System
ISO	International Standards Organization
IUR	Inhalation Unit Risk
L	liter
NCP	National Contingency Plan
OSC	On-Scene Coordinator
PCM	phase contrast microscopy
PCME	phase contrast microscopy equivalent
PEL	permissible exposure limit
PLM	polarized light microscopy
REAC	EPA's Response Engineering and Analytical Contract
RME	reasonable maximum exposure
s/cc	structures per cubic centimeter
sq. ft.	squared foot
TEM	transmission electron microscopy
TWF	time-weighting factor
µm	micrometer

1. INTRODUCTION AND SITE BACKGROUND

The GAO 148 site is located at 13101 Highway 221, Woodruff, Spartanburg County, South Carolina. Figure 1-1 shows the site location and Figure 1-2 presents the overall site layout, including the approximate property boundary. The site covers about 23 acres, and includes two businesses: Palmetto Vermiculite, Inc., which generally occupies the northwestern portion of the property; and Quality Haulers, Inc., which generally occupies the southeastern portion of the property. The portion of the property occupied by Palmetto Vermiculite, Inc. was the focus of this investigation and the remainder of this section describes only that portion of the property (Tetra Tech, 2011).

The portion of the property occupied by Palmetto Vermiculite, Inc. consists of a large building complex, including offices, vermiculite exfoliation furnaces, hoppers, conveyors, silos, and related machinery. There are several large, covered storage bays where materials including what is reportedly concentrated vermiculite from various sources are stored, as well as other machinery and equipment. Products sold by Palmetto Vermiculite, Inc. include exfoliated vermiculite, cement, gravel, and sand.

The building complex has exterior walls that covered part but not all the perimeter of the complex, which left large portions of the interior of the complex open to the outside. The remaining portion of the property occupied by Palmetto Vermiculite, Inc. consisted of bare ground, gravel-covered areas, and areas covered in low vegetation.

The available file material indicates that the GAO 148 site is the location of a former and currently-operating vermiculite exfoliation facility that processes vermiculite obtained from both domestic and foreign sources. The facility reportedly began operations in 1988, although some files suggest that vermiculite exfoliation operations may have begun at the site as early as 1964. The vermiculite exfoliation facility has reportedly purchased vermiculite ore from suppliers located in South Carolina, Virginia, Georgia, New Jersey, South Africa, and China. The facility reportedly processes vermiculite for use in horticultural products, lightweight cements, plaster, and other products. A U.S.

Environmental Protection Agency (EPA) database compiled from W.R. Grace shipping invoices did not contain any records indicating that vermiculite ore from the W.R.Grace vermiculite mine in Libby, Montana were shipped to the GAO 148 site. Palmetto Vermiculite, Inc. has claimed that it never purchased, received or processed any ore from Libby.

Samples of various ores, waste rock, and finished product were collected at the site by EPA in 2001. The samples were submitted for analysis for asbestos by polarized light microscopy (PLM) and asbestos was not detected in any of the samples. However, the report stated that "Mineral Fibers of Concern" were identified in two of the samples. These fibers represented a class of amphibole categories that has been identified by EPA Region 8 to be associated with Libby, MT asbestos. These include richterite and winchite. Based on information gathered regarding the GAO 148 site, EPA concluded that further investigation at the site was required (Tetra Tech, 2011).

1.1 PROJECT OBJECTIVE

The primary objective of this human health risk assessment (HHRA) report is to evaluate the potential human health risks from exposure to asbestos at the Site based on activity-based sampling (ABS) activities performed in December, 2009.

1.2 HHRA FORMAT

This HHRA has been organized as follows:

- Section 1 – Introduction and Site Background
- Section 2 – Goal of the Human Health Risk Assessment
- Section 3 – Data Evaluation and Exposure Assessment
- Section 4 – Toxicity Assessment
- Section 5 – Risk Characterization
- Section 6 – Uncertainty Analysis

- Section 7 – Summary
- Section 8 – References

2. GOAL OF THE HUMAN HEALTH RISK ASSESSMENT

The goal of the human health risk assessment is to use current best practice asbestos sampling and analytical techniques to estimate the potential excess lifetime cancer risks associated with those exposures that could occur at the site. This assessment was conducted in accordance with EPA policy and guidance (EPA, 2008). The assessment consists of four parts:

- Exposure Assessment (Section 3) – describes the methods by which the asbestos data used in the HHRA were collected; presents the analytical results of the sampling in tabular format; and presents the manner in which the available asbestos data were used to estimate excess lifetime cancer risks.
- Toxicity Assessment (Section 4) – describes the cancer potency for asbestos and presents a table that summarizes the various cancer potency values based on age of onset and duration of exposure.
- Risk Characterization (Section 5) – presents the equation that was used to estimate the excess lifetime cancer risks and summarizes the exposure scenario-specific parameters that were used. Presents excess lifetime cancer risks for each of the scenarios, with results and conclusions.
- Uncertainty Analysis (Section 6) – discusses the various sources of uncertainty associated with the HHRA process and indicates the potential impact to the estimate of risks (under- or overestimate).

3. DATA EVALUATION AND EXPOSURE ASSESSMENT

The objectives of the data evaluation and exposure assessment are to:

- Describe the methods that were followed to collect asbestos data for use in the HHRA (Subsection 3.1).
- Present the sampling results for each of the sample collection methods (Subsections 3.2 – 3.4).
- Present the manner in which the data were evaluated in the HHRA (Subsection 3.5).
- Perform Exposure Assessment (Subsection 3.6).

3.1 SAMPLING METHODS

In December 2009, a sampling effort was conducted to further investigate the presence of asbestos at the Site and to determine the possible mechanism of exposure. The collected samples included:

- Air Samples – activity-based and stationary samples collected during activities (e.g., sweeping paved areas) that could result in exposure.
- Background Air Samples – stationary samples to determine if measurable levels of asbestos existed in background concentrations not associated with the Site.
- Bulk Samples – a method designed to determine the presence of asbestos in soil.

The air sampling (including activity-based, stationary, and background samples) was conducted using modified International Standards Organization (ISO) Method 10312. A detailed discussion of how this procedure was applied is presented in the Sampling and Analysis Plan (Tetra Tech, 2009). The subsections below describe each of the sample collection methods and how the data were used in the HHRA.

3.2 ACTIVITY-BASED SAMPLING

The primary data for quantifying health risks in this HHRA were collected using ABS techniques. A number of sources indicate that personal monitoring is more representative of actual exposure than samples obtained from a fixed downwind location (McBride, 1999; Rodes, 1991 and 1995; Hildemann, 2005). ABS directly measures the asbestos levels in the breathing zone of an individual, making it a more accurate predictor of exposure than static, stationary monitors. Thus, personal monitoring results are generally most relevant to CERCLA risk characterizations and were used where possible in the HHRA to estimate the excess lifetime cancer risks.

ABS utilizes personal air monitoring. Personal air monitoring is a well-established approach that has been used for decades by industrial hygienists for exposure assessment in occupational environments. It is well-suited for environmental asbestos exposure measurements because it captures the asbestos structures in the personal dust cloud that is generated by activities that disturb asbestos-containing soils. The breathing zone can be visualized as a hemisphere extending approximately 6 to 9 inches around an individual's face.

EPA has developed ABS to mimic the activities of a potential receptor. EPA or contractor personnel trained in hazard recognition and mitigation serve as surrogates for the potentially exposed populace of interest. Routine activities are simulated to measure personal exposures from disturbance of materials potentially contaminated with asbestos. ABS samples collected during normal working activities, sweeping, and raking were used to evaluate potential exposure in this HHRA.

The total time of each ABS event was approximately 120 minutes. One high flow-rate air pump and one low flow-rate air pump were carried in a backpack on each of the participant's backs, and the inlets of the air filter cassettes were secured to the participant's shoulder straps so that the inlets were within the participant's breathing zone. At each location where an activity was performed, the ABS sample collected using the high flow-rate pump was analyzed first, and if overloaded, the low flow-rate sample was analyzed.

The air sample data were reported as phase contrast microscopy (PCM) equivalent fiber concentrations. The PCM method of quantification was utilized because this is the traditional method for measurement of asbestos fibers in air, and is the basis for current estimates of risk. PCM fibers are equal to or longer than 5 µm, at least 0.25 µm thick, and have an aspect ratio of at least 3:1. Fibers that are observed using transmission electron microscopy (TEM) that have these attributes are referred to as PCM-equivalents (PCMe). In this report, the term fibers per cubic centimeter (f/cc) will be used when referring to IRIS toxicity data and other applicable standards. The air concentrations are reported as structures per cubic centimeter (s/cc) which are intended to mimic the size fraction of fibers that would be detected if the sample was being run under standard PCM. Concentrations reported as s/cc can be directly compared to standards developed as f/cc.

Three rounds of ABS were performed at the Site. The locations of each ABS event are presented in Figure 3-1 (ABS Rounds 1 and 2) and Figure 3-2 (ABS Round 3). The following samples were collected at each ABS location: breathing zone sample collected during simulated activity (except for Round 1), one upwind stationary sample, and three downwind stationary samples. A multi-point composite bulk material sample was collected in association with ABS air sampling Round 3, from within the area where the activity occurred after the round was completed. Bulk material samples were not collected in association with ABS Rounds 1 and 2 because they were performed inside the building. Additional bulk sampling was performed at locations inside the building (see Figure 3-3).

Upwind and downwind locations, as well as background locations, were determined based on personal observations by the field team and expected wind direction during the upcoming day. An on-site meteorological station was also used during the ABS sampling, but equipment problems and the variable wind conditions experienced during the sampling preclude the use of this information for understanding wind direction variability during the collection period. Given the changing meteorological conditions, as well as the influence of local structures, including two of the events occurring inside the building, designations of upwind and downwind are ambiguous at best and cannot be used to conclusively establish upwind and downwind conditions.

Table 3-1 presents the results of the samples collected from the three ABS rounds. The table presents the location, the sample number for each sample collected from that location, a brief description of the sample, the PCME concentration in s/cc, and the types of asbestos found.

The subsections that follow discuss the ABS events in greater detail. The site-specific information in the subsections that follow was taken from the Draft Removal Assessment Report (Tetra Tech, 2011).

It should be noted that indoor aggressive air sampling (and associated bulk material sampling) activities were not conducted at the GAO 148 site. This was due to the building's structure, which left large portions of the interior of the complex open to the outside. It was determined by the EPA On-Site Coordinator (OSC) that the building complex was too open to conduct a meaningful indoor aggressive air sampling event.

Instead of aggressive indoor air sampling, two ABS rounds were conducted at separate locations inside the building complex. The first round of sampling conducted inside the structure did not include a simulated activity or a breathing zone sample; instead, several stationary, perimeter high and low flow rate air sample sets were arrayed around an area where actual Palmetto Vermiculite, Inc. personnel were conducting work activities as a surrogate for true ABS. The second ABS round of sampling involved the performance of a simulated activity in the form of sweeping by EPA personnel, although Palmetto Vermiculite, Inc. personnel were also conducting work activities in the vicinity during this ABS round. The third round of ABS was conducted outside and involved EPA personnel conducting a simulated raking activity (Tetra Tech, 2011).

3.2.1 Activity-Based Sampling Round 1: Normal Working Conditions

On December 2, 2009, ABS Round 1 was conducted inside the building structure with no simulated activity (stationary monitors), but with the typical worker activities ongoing. These activities included bagging of materials and moving materials using a hand cart and a forklift. The activity area was located inside the central portion of the large building complex at the GAO 148 site, adjacent to the southeastern side of the structure. This area was chosen for sampling because it encompassed an area where Palmetto Vermiculite, Inc. personnel were observed to be working, which enabled collecting air samples in the proximity of actual work being conducted as opposed to a simulated activity. The area inside the building complex where ABS Round 1 was conducted was adjacent to an opening in the complex's exterior wall and was therefore susceptible to the influence of wind and weather to some degree.

ABS Round 1 was conducted for 120 minutes. Four sets (plus an additional field duplicate sample set) of collocated ABS perimeter high flow rate and low flow rate air samples were placed around the activity area, with one set (with the field duplicate) designated as upwind and three sets designated as downwind (Figure 3-1). Bulk material samples were not collected from within the activity area for Round 1.

Asbestos was detected in all of the ABS Round 1 samples ranging from 0.0039 to 0.033 s/cc. Asbestos was detected in the three "downwind" perimeter samples at levels of 0.033, 0.0039, and 0.0049 s/cc (G148-AB1-PL-08, -04, and -06 respectively). The "upwind" sample and its' duplicate ranged from 0.019 to 0.023 s/cc (G148-AB1-PL-02). As noted above, the upwind and downwind descriptors are probably not accurate given the conditions inside the building during the sampling period, and these results may be considered generally indicative of the concentrations in that portion of the building during the test.

3.2.2 Activity-Based Sampling Round 2: Sweeping

On December 2, 2009, ABS Round 2 was conducted and involved sweeping an area of concrete floor located inside the central portion of the large building complex. The activity area was located adjacent to the northwestern side of the structure, amid hoppers and other machinery (Figure 3-1). This area was chosen for ABS because it is located near machinery and operations reportedly involved in processing and exfoliating vermiculite. In fact, during ABS Round 2, Palmetto Vermiculite, Inc. personnel used a small front-end loader to periodically transport and load material (possibly vermiculite concentrate) into hoppers that were located adjacent to the activity area. Openings in exterior walls combined with the absence of interior walls in some places prevented the activity area from being isolated from either the outside or other adjoining interior spaces in the building complex. Other operations including the exfoliation of vermiculite and the transport of material on an elevated conveyor belt were reportedly also occurring in the building complex during ABS Round 2.

ABS Round 2 was conducted for about 120 minutes, although the sweeping activity occurred intermittently over three separate periods of the two-hour round in an effort to preclude overloading of the ABS backpack and perimeter air samples. Whether sweeping was occurring or not, however, all air sample pumps were left running during the entire two-hour sampling round, including the ABS backpack high flow rate and low flow rate air sample pumps. In addition, whenever the sweeping participant was not sweeping, the participant remained within the designated activity area.

One set of collocated ABS backpack high flow rate and low flow rate air samples (plus a field duplicate sample accompanying the low flow rate sample) were collected using two participants alternating turns. Four sets of collocated ABS perimeter high flow rate and low flow rate air samples were placed around the activity area, with one set designated as upwind and three sets designated as downwind (Figure 3-1). Bulk material samples were not collected from within the activity area for Round 2 (Tetra Tech, 2011).

Asbestos was not detected in the primary ABS Round 2 sample (G148-AB2-AL-18), but was detected in the duplicate at 0.004 s/cc (G148-AB2-AL-18-DUP). Asbestos was detected in two of the three "downwind" perimeter samples at levels of 0.01 (G148-AB2-PL-12), and 0.0077 (G148-AB2-PL-16), but not detected in the other (G148-AB2-PL-14). The "upwind" sample was reported at a concentration of 0.004 s/cc (G148-AB2-PL-10). As noted above, the upwind and downwind descriptors are probably not accurate given the conditions inside the building, and these results should be considered generally indicative of the concentrations in that portion of the building during the test.

3.2.3 Activity-Based Sampling Round 3: Raking

On December 3, 2009, ABS Round 3 was conducted and involved raking in a low area located in the northern portion of the site property, northwest of the large building complex at the site (see Figure 3-2). The activity area consisted of bare ground littered with gravel and debris and sparsely covered with low vegetation. This area was chosen to conduct an ABS round because it is a low area that appeared to receive surface water drainage from the large building complex and its immediate vicinity.

Material that looked like vermiculite was observed within and on the ground surrounding the ditch. Operations such as the exfoliation of vermiculite were possibly being conducted at the GAO 148 site during the air sampling round. ABS Round 3 was conducted for 120 minutes. Both a leaf rake and a garden rake were used to conduct the raking activity during the round. The leaf rake was used to rake from all four edges of the approximately square activity area, then the garden rake was used to conduct the next sequence of raking from the same four edges, then raking with the leaf rake was resumed, and so on in alternating fashion.

One set of ABS backpack high flow rate and low flow rate air samples were collected using two participants alternating raking activities. Four sets of collocated ABS perimeter high flow rate and low flow rate air samples were placed around the activity area, with one set designated as upwind and three sets designated as downwind. At the end of ABS

Round 3, a five-point composite bulk material sample (G148-AB3-B-35) was collected from within the area that was raked (Tetra Tech, 2011).

Asbestos was not detected in any of the air samples associated with ABS Round 3. The bulk composite sample was also nondetect for asbestos, at a 0.25% analytical detection limit.

3.3 BACKGROUND SAMPLING

Background air samples are typically collected off site or at the site perimeter and upwind at a distance sufficient to prevent real-time influence by ABS activities at the site. A background air sample was collected on only one of the two days of sampling during the December 2009 field event at the GAO 148 site. On December 2, 2009, background air sampling was not conducted due to the occurrence of heavy rain. On December 3, 2009, however, background air sample G148-BKA-19 was collected. Asbestos was not detected in the background air sample.

3.4 BULK SAMPLING

The bulk samples were analyzed using the CARB 435 Method, which achieves a low level of detection (0.25%). As discussed in the previous sections, a bulk sample was collected for Round 3, which was non-detect for the five point composite.

Samples of bulk material not associated with the ABS rounds were designated as "additional" bulk material samples. Additional bulk material samples may consist of debris, soil, or other material associated with historical or current site operations. Four additional bulk material samples (G148-BS-31 through -34) were collected on December 3, 2009 from locations within the large building complex. All four samples were grab samples collected from separate piles of what was reportedly concentrated vermiculite from various sources and all were non-detect at a 0.25% analytical detection limit.

3.5 DATA TREATMENT

The approach to evaluating data for each sampling method described above is presented below:

- ABS Sampling – the indoor site worker exposure scenario described in Section 3.6 was evaluated based on the asbestos results from the two ABS rounds conducted inside (Rounds 1 and 2). Since these locations are in close proximity to each other and could represent exposure to all indoor site workers, two exposure point concentrations (EPCs) were developed: the average of all nine samples collected during these two Rounds, assuming the duplicates were averaged, represents the average Site-wide average EPC (0.01 s/cc), and the highest concentration measured represents the Site maximum EPC (0.033 s/cc). Round 3 had no detected concentrations of asbestos and no risks are estimated.

- Background Air Samples – the single background sample was non-detect for asbestos.

- Bulk Samples – the bulk samples were all non-detect with a 0.25% analytical detection limit. Bulk sample data were not used in the calculation of risk.

3.6 EXPOSURE ASSESSMENT

The exposure assessment consists of several steps including:

- Developing a conceptual site model.

- Determining the potentially exposed population(s).

- Identifying exposure pathways to be quantified in the risk assessment.

A conceptual site model (CSM) describes the contaminant sources, the exposure media, the exposure routes, and the potentially exposed populations. The primary objective of the conceptual site model is to identify complete and incomplete exposure pathways. A complete exposure pathway has all of the above-listed components, whereas an incomplete pathway is missing one or more.

The single scenario evaluated was based on exposure to indoor site workers as a result of dust generating activities. This scenario was represented by an adult who works in the partially open main building on the Site. The period of exposure was assumed to begin at age 20.

Other scenarios were considered such as future residential and recreational exposure. However, given the current and anticipated future uses of the site, it is unlikely that either scenario would occur at any point in time in the future. If land uses change such that such a scenario was likely, the risks associated with potential exposure would need to be reconsidered.

To provide a range of exposure and risks, the reasonable maximum exposure (RME) and central tendency exposure (CTE) scenarios were evaluated (EPA, 1992). The RME, an estimate of the high-end exposure in a population, is based on a combination of average and high-end estimates of exposure parameters typically representing the 90th percentile or greater of actual expected exposure. The CTE represents an estimate of the average exposure in a population and is based on central estimates of exposure parameters.

4. TOXICITY ASSESSMENT

The primary purpose of the toxicity assessment is to identify the toxicity values for evaluating the impacts of asbestos exposure. The risk estimates used to derive the current inhalation unit risk (IUR) presented in the Integrated Risk Information System (IRIS) were based on a synthesis of published epidemiological studies currently available (EPA, 2010). Risk of lung cancer and mesothelioma from asbestos exposure in different occupational cohorts were considered discreetly and then summed to generate a value used to estimate total lifetime risk. EPA currently uses an IUR value of 0.23 per PCM fibers per cubic centimeter $(f/cc)^{-1}$.

The IRIS program is undertaking a reassessment of risks associated with asbestos exposure to provide an update of the current understanding of asbestos carcinogenicity and to adjust the potency factor (i.e., the IUR value previously described) as needed. There are a number of areas of uncertainty associated with the current unit risk value that may be taken into account in any new IRIS value including the following:

- Mineral present at the site (amphibole forms may have a different potency from chrysotile).
- Size distribution of materials at the site (length, width, aspect ratio) may differ from those used in the IRIS assessment.
- Potential for less than lifetime exposures.

While some of these uncertainties can only be addressed qualitatively at the present time, the potential for increased risk for certain subpopulations based on age at onset of exposure and the duration of exposure(s) can be evaluated through the use of alternative IURs. Table 4-1 presents both the lifetime IUR and the less-than-lifetime IURs that were used in the analysis of carcinogenic risk for each of the exposure scenarios (EPA, 2008).

EPA currently has no methods available for evaluating any of the non-cancer health effects of asbestos despite clear evidence that asbestosis and other non-cancer related health conditions are caused by exposure to asbestos. Non-cancer effects of asbestos are discussed in the Uncertainty Analysis in Section 6.0.

Table 4-1

Lifetime Inhalation Unit Risk (IUR) $(f/cc)^{-1}$ and Less-than-Lifetime Inhalation Unit Risk (IUR_{LTL}) $(f/cc)^{-1}$ Values for Various Continuous Exposure Scenarios

Age at first exposure (years)	Duration of exposure (years)										
	1	5	6	8	10	20	24	25	30	40	Life-time
0	0.010	0.047	0.055	0.071	0.085	0.14	0.15	0.16	0.17	0.19	0.23*
1	0.0099	0.045	0.053	0.068	0.081	0.13	0.15	0.15	0.17	0.19	
5	0.0085	0.039	0.046	0.058	0.070	0.11	0.13	0.13	0.14	0.16	
10	0.0070	0.032	0.038	0.048	0.057	0.092	0.10	0.10	0.11	0.13	
20	0.0049	0.022	0.026	0.033	0.039	0.062	0.068	0.069	0.075	0. 083	
30	0.0034	0.015	0.018	0.022	0.026	0.040	0.044	0.045	0.048	0.052	

* Lifetime in this table means continuous lifetime exposure beginning at birth and lasting until death of the individual. Continuous means that exposure occurs 24 hours/day, 365 days/year.

Values obtained from EPA, 2008.

All values are shown to two significant figures.

5. RISK CHARACTERIZATION

The risk characterization presents the approach to estimating risk, the exposure scenario and exposure factors applied in the risk analysis, and the quantitative risk estimates, as well as a summary of the results and conclusions of the risk assessment.

5.1 RISK CALCULATION METHOD

The applicable ABS data were used to develop the EPC that was used to calculate the excess lifetime cancer risk (ELCR) for the indoor site worker exposure scenario (described in the exposure assessment). The general equation for estimating risks from inhalation to asbestos is:

$$ELCR = EPC \times IUR \times TWF$$

Where:

ELCR	=	Excess Lifetime Cancer Risk, the risk of developing cancer as a consequence of the site-related exposure.
EPC	=	Exposure Point Concentration (s/cc).
IUR	=	Inhalation Unit Risk $(f/cc)^{-1}$.
TWF	=	Time Weighting Factor (unitless), this factor accounts for less-than-continuous exposure during a 1-year exposure.

Each of the input parameters needed to calculate the ELCR is discussed below.

5.1.1 Exposure Point Concentration

The concentrations of asbestos fibers in air (s/cc) were determined based on the ABS personal breathing zone sampling results in Round 2 and all the perimeter samples from Rounds 1 and 2. While this is not typical in a risk assessment of this type, it was determined that given the proximity of the sample rounds, the open nature of the structure which would reduce the variability between the sample locations, and the fact that ABS was only conducted during Round 2 for reasons previously stated, this approach was the most reasonable available to characterize Site risks. As described in Section 3, asbestos was detected in two of the three rounds. A site maximum (0.033 s/cc) was calculated for use as the reasonable maximum exposure (RME), and an overall site average (0.011 s/cc) was calculated for use for as the central tendency exposure (CTE). Both values were used to estimate potential risk to the indoor worker.

5.1.2 Inhalation Unit Risk

Based on the assumed age when exposure begins for the worker (age 20) and the duration of the exposure, the IUR value presented in Table 4-1 was selected and was used to estimate a range of excess lifetime cancer risk. Table 5-1 presents the selected IURs for the RME and CTE scenarios.

Table 5-1

Summary of Exposure Parameters – Worker Exposure

Hours per Day	Days per Year	TWF	Age at Onset of Exposure	Exposure Duration (years)	IUR $(f/cc)^{-1}$ (EPA, 2008)
Reasonable Maximum Exposure					
See below	See below	0.357*	20	25	0.069
Central Tendency Exposure					
See below	See below	0.357*	20	7**	0.033

EPA, 2008 – Framework for Investigating Asbestos-Contaminated Superfund Sites
* TWF for the worker is the inverse of the adjustment factor of 2.8 that was used by IRIS to extrapolate from workers to continuous exposure.
** EPA, 1997 – median value from Table 15-158.

5.2 EXPOSURE PARAMETERS

The TWF for the worker scenario was the inverse of the adjustment factor of 2.8 that was used by IRIS to extrapolate from worker to continuous exposure. Site workers were assumed to be exposed to asbestos while working inside the building. It was assumed that they start working at age 20 and continued at the same location for 25 years for the RME (default worker duration) and 7 years for the CTE (EPA, 1997).

5.3 RISK ESTIMATES

The RME and CTE risks were calculated based on EPCs of 0.033 s/cc (maximum) and 0.01 s/cc (average). The risks are calculated and presented on Table 5-2 and summarized below.

Exposure Scenario	EPC (s/cc)	RME ELCR	CTE ELCR
Indoor Worker	0.033 (Site maximum)	8E-04	4E-04
Indoor Worker	0.01 (Site average)	3E-04	1E-04

5.4 EVALUATION OF INDOOR AIR SAMPLES

ABS Rounds 1 and 2 sampling events were both indoor air sampling events in an active work place. Therefore, in addition to the estimation of cancer risk, the concentrations were also compared to the Occupational Safety and Health Administration time-weighted average PEL for asbestos of 0.1 f/cc. None of the indoor air concentrations exceeded the PEL.

5.5 RESULTS AND CONCLUSIONS

EPA has established an acceptable ELCR range that is expressed as a probability between 1E-04 and 1E-06. ELCRs calculated to be less than the low end of the range, 1E-06, are said to be *de minimis* (minimal) and generally do not need to be considered further. Risks greater than 1E-06 but less than 1E-04 are within EPA's acceptable risk range. Risks greater than 1E-04 exceed the risk range and may require that an action be taken to reduce the potential risks. The designated risk managers for a site ultimately decide whether an action is necessary based upon a variety of considerations.

The risks to the current indoor site worker were above the acceptable risk range for the RME and CTE scenarios for both the maximum and site average EPC. This was the only potential exposure pathway quantified because the active nature of the site is likely to preclude residential exposure and any other less intensive exposure. Should future actions at the Site result in changes in potential use and exposure, the results and conclusions of the risk assessment would need to be re-evaluated.

6. UNCERTAINTY ANALYSIS

All risk assessments have some level of uncertainty associated with them. The goals of an uncertainty analysis are to provide to the appropriate decision makers (i.e., risk managers) information about the key assumptions, their inherent uncertainty and variability, and the impact of this uncertainty and variability on the estimates of risk. The uncertainty analysis should show that risks are relative in nature and do not represent an absolute quantification. This is an important point that is vital to the proper interpretation and understanding of the risks presented in this report. Conservative assumptions were used throughout this risk assessment in an attempt to balance some of these uncertainties.

Uncertainties and limitations of this risk assessment include the following:

- ABS directly measures the asbestos levels in the breathing zone of an individual, making it a more accurate predictor of exposure than static, stationary monitors. Thus, personal monitoring results are generally most relevant to CERCLA risk characterizations. However, in the first round of samples collected for this investigation, stationary monitors were used as a surrogate for ABS inside an active work area. Actual fiber concentrations in a workers breathing zone may have been higher or lower than those measured using this surrogate method.

- The asbestos air data upon which the risk estimates were based are limited. It includes ABS results collected during three sampling rounds, two of which were inside a Site building. In reality, exposure over a lifetime would be based on a wide variety of physical conditions, some of which may increase or decrease exposure and risk as compared to those at the time of the ABS. Actual conditions over a lifetime could result in either higher or lower exposure concentrations.

- The IRIS Inhalation Unit Risk for asbestos was based on epidemiological data from groups exposed to asbestos fibers that typically did not include amphibole asbestos, which is the predominant type of fiber associated with Libby Mine vermiculite and the predominant type of fiber found on this Site. The toxicity of amphibole asbestos may be different from other forms of asbestos. Furthermore, EPA is intending to modify the Inhalation Unit Risk for amphibole asbestos at some point in the future. Risks may need to be revisited when any change to this factor is finalized.

- The metric used to evaluate inhalation exposure was PCMe. There is not a clear consensus in the scientific community as to whether this metric captures the entire range of asbestos fibers that could cause disease, especially in a case like this Site where amphibole fibers predominate. To the degree that some categories of fibers that are currently not counted in the PCMe-based concentration estimates could contribute to adverse health impacts, risks could be underestimated.

- EPA has no methods available for estimating noncancer risks from asbestos exposure. Asbestosis and other non-malignant asbestos-related diseases are known to occur to individuals exposed to asbestos. Evaluating only the cancer risks associated with exposure at the Site underestimates this potential health risk, potentially to a significant degree.

- Activities other than those evaluated at the Site, based on raking and sweeping scenarios, could occur in the future to potentially exposed receptors. This could include activities with a greater or lesser potential for releasing dusts, and therefore asbestos, and a greater or lesser potential for inhalation, based on presumed inhalation rates. This could result in the predicted risks being either over- or underestimated.

7. SUMMARY

The HHRA focused on the potential asbestos risks from inhalation exposure estimated from the ABS sampling activities at the site. The ABS-based inhalation risks for the recreational receptors were above the upper end of EPA's risk range. Although the facility has reportedly never received vermiculite from Libby, Montana, asbestos identified by the laboratory as Libby amphibole was identified in air samples collected within the operational facility. Asbestos was not detected in the bulk samples collected during this investigation, so the source of the asbestos (including Libby amphibole fibers) is not currently known. As described in the Uncertainty Analysis, there is a considerable degree of uncertainty associated with estimated risks derived from the ABS sampling.

8. REFERENCES

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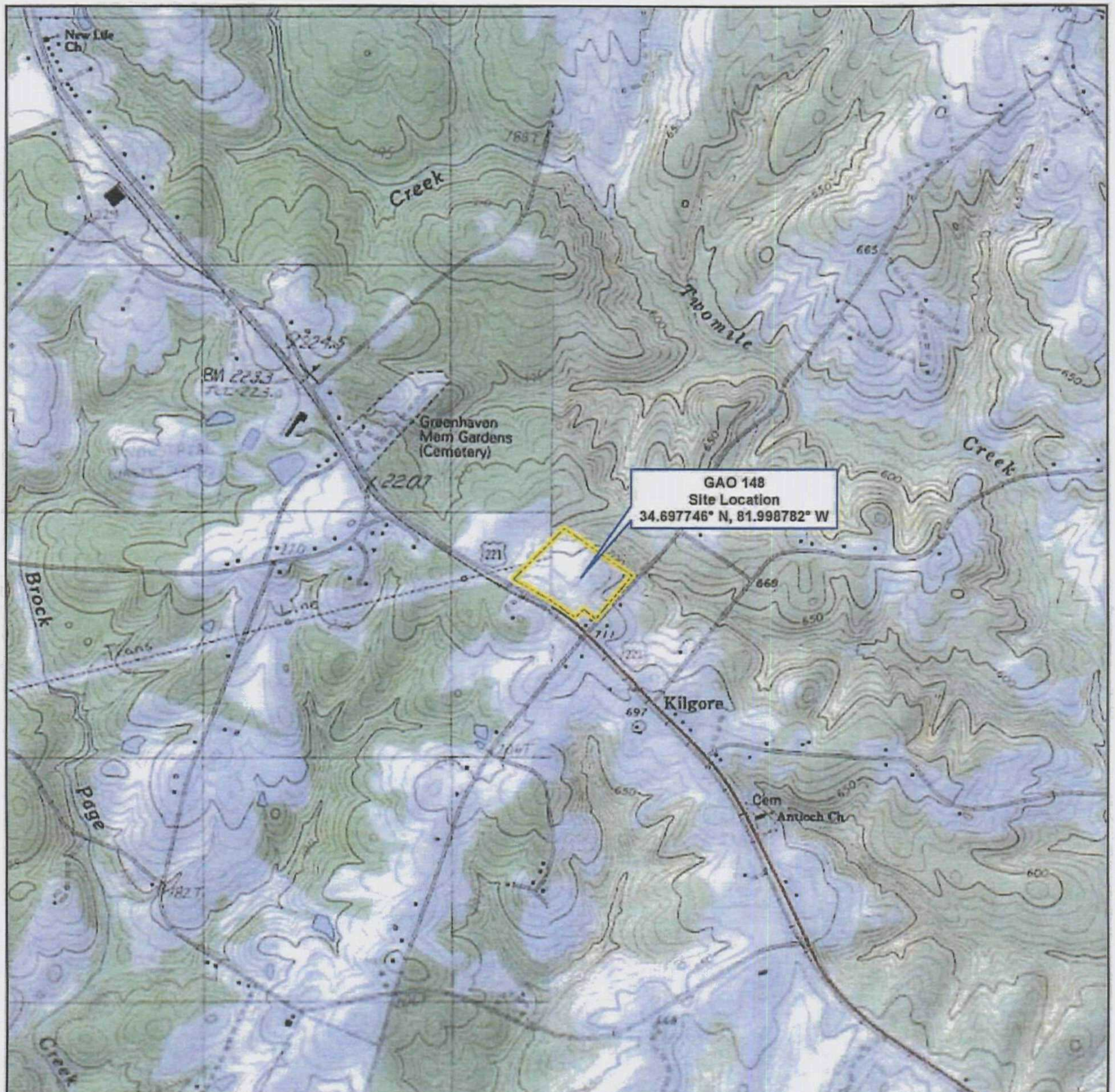


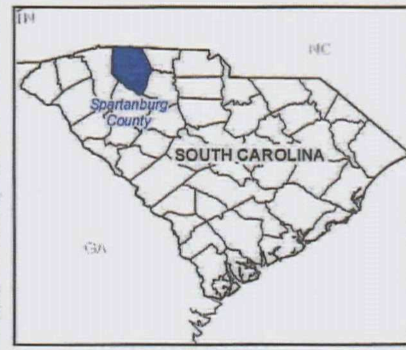
Legend

Approximate Property Boundary

N
W E
S

0 1,000 2,000 Feet

Map Source:
USGS Topographic Quadrangle Maps,
Woodruff, SC 1984 & Encree, SC 1973



United States
Environmental Protection Agency

VERMICULITE EXFOLIATION SITE
GAO 148
WOODRUFF,
SPARTANBURG COUNTY,
SOUTH CAROLINA
TDD No.TTEMI-05-003-0078

FIGURE 1-1
SITE LOCATION

TETRA TECH

VERMICULITE EXFOLIATION SITE
GAO 148
WOODRUFF,
SPARTANBURG COUNTY,
SOUTH CAROLINA
TDD No.TTEMI-05-003-0078

FIGURE 1-2
SITE LAYOUT

TETRA TECH

Legend

- Station Identification
- Sample Designation
- Air Sample
- Meteorological Station
- Approximate Property Boundary
- Activity Area

N
W E
S

0 30 60
Feet

Map Source:
Aerial Imagery - ESRI I3 Imagery Prime, 2009

United States
Environmental Protection Agency

VERMICULITE EXFOLIATION SITE
GAO 148
WOODRUFF,
SPARTANBURG COUNTY,
SOUTH CAROLINA
TDD No.TTEMI-05-003-0078

FIGURE 3-1
SAMPLE LOCATIONS FOR ACTIVITY-BASED AIR SAMPLING ROUNDS 1 & 2
DECEMBER 2, 2009

TETRA TECH

Legend

- Station Identification
- Sample Designation
- Meteorological Station
- Air Sample
- Activity Area
- Approximate Property Boundary

N
W E
S

0 30 60 Feet

Map Source:
Aerial Imagery - ESRI I3 Imagery Prime, 2009

United States
Environmental Protection Agency

VERMICULITE EXFOLIATION SITE
GAO 148
WOODRUFF,
SPARTANBURG COUNTY,
SOUTH CAROLINA
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FIGURE 3-2
SAMPLE LOCATIONS FOR ACTIVITY-BASED AIR SAMPLING ROUND 3
DECEMBER 3, 2009

TETRA TECH

Legend

- Station Identification
- Sample Designation
- Bulk Sample Point
- Piles
- Approximate Property Boundary
- Approximate Wall Locations

N
W E
S

0 25 50 Feet

Map Source:
Aerial Imagery - ESRI I3 Imagery Prime, 2009

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VERMICULITE EXFOLIATION SITE
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WOODRUFF,
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FIGURE 3-3
ADDITIONAL BULK MATERIAL SAMPLING
DECEMBER 3, 2009

TETRA TECH

Table 3-1
Analytical Results Summary

Sampling Program	Sample Number	Description	PCMe Concentration (s/cc)	Observed Fiber Type
Activity Based Sampling Round 1 Normal Working Conditions	G148-AB1-PL-02	Upwind Perimeter	0.023	Actinolite, Libby amphibole
	G148-AB1-PL-02-DUP	Upwind Perimeter	0.019	Actinolite, Libby amphibole
	G148-AB1-PL-04	Downwind Perimeter	0.0039	Libby amphibole, anthophyllite
	G148-AB1-PL-06	Downwind Perimeter	0.0049	Actinolite, Libby amphibole
	G148-AB1-PL-08	Downwind Perimeter	0.033	Actinolite, Libby amphibole
Activity Based Sampling Round 2 Sweeping	G148-AB2-AL-18	ABS	0	---
	G148-AB2-AL-18-DUP	ABS	0.004	Libby amphibole, anthophyllite
	G148-AB2-PL-10	Upwind Perimeter	0.004	Actinolite, Libby amphibole, anthophyllite
	G148-AB2-PL-12	Downwind Perimeter	0.01	Actinolite, Libby amphibole, anthophyllite
	G148-AB2-PL-14	Downwind Perimeter	0	---
	G148-AB2-PL-16	Downwind Perimeter	0.0077	Libby amphibole, actinolite
Activity Based Sampling Round 3 Raking	G148-AB3-AH-28	ABS	0	---
	G148-AB3-PH-20	Upwind Perimeter	0	---
	G148-AB3-PH-22	Downwind Perimeter	0	---
	G148-AB3-PH-24	Downwind Perimeter	0	---
	G148-AB3-PH-26	Downwind Perimeter	0	---
	G148-AB3-B-35	Bulk sample	ND	---
Additional Bulk Sampling	G148-BS-31	Bulk sample	ND	---
	G148-BS-32	Bulk sample	ND	---
	G148-BS-33	Bulk sample	ND	---
	G148-BS-34	Bulk sample	ND	---
Reference	G148-BKA-29	Air	0	---

ABS = activity-based sampling

s/cc = structures per cubic centimeter

PCMe = phase contrast microscopy equivalent

Table 5-2

Estimated Cancer Risks for Activity Based Sampling - Worker

Exposure Scenario	PCMe Concentration (s/cc)	IUR $(f/cc)^{-1}$	TWF	Cancer Risk
Reasonable Maximum Exposure - Site Maximum EPC				
Commercial/Industrial Worker				
Indoor Activities	0.033	0.069	0.357	8E-04
Reasonable Maximum Exposure - Site-Wide Average EPC				
Indoor Activities	0.01	0.069	0.357	2E-04

Central Tendency Exposure - Site Maximum EPC				
Commercial/Industrial Worker				
Indoor Activities	0.033	0.033	0.357	4E-04
Central Tendency Exposure - Site-Wide Average EPC				
Indoor Activities	0.01	0.033	0.357	1E-04